DOCUMENT RESUME

ED 398 366 CE 070 970

TITLE	Instructional Technology [in HRD].
PUB DATE	Mar 95
NOTE	20p.; In: Academy of Human Resource Development (AHRD) Conference Proceedings (St. Louis, MO, March 2-5, 1995); see CE 070 958. For other conference symposia, see CE 070 959-981. Simon and Palmer and Rhodes are not included due to copyright restrictions.
PUB TYPE	Speeches/Conference Papers (150)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	Adult Education; *Adult Learning; *Computer Assisted Instruction; Foreign Countries; *Instructional Design; *Labor Force Development; *Performance Technology; Research Needs
IDENTIFIERS	Netherlands; *Performance Support Systems

ABSTRACT

These four papers are from a symposium that was facilitated by C. J. Wallington at the 1995 conference of the Academy of Human Resource Development (HRD). "The Effectiveness of an Electronic Performance Support System (EPSS) on Learning and Performance" (Theo J. Bastiaens, Wim J. Nijhof, Harmen J. Abma) reports on a study of Dutch insurance agents using laptops that identified some major advantages of EPSS, such as increased productivity and better learning outcomes, and found no significant improvement in productivity or learner outcomes. "Principles of Computer-Based Instruction (CBI) Design and the Adult Learner: The Need for Further Research" (Reid A. Bates, Dian L. Seyler, Elwood F. Holton, III) surveys research literature to identify the principles of effective CBI, assesses the adequacy of the research, and makes recommendations for a research agenda related to CBI, adults, and the workplace. (YLB)

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ACADEMY OF HUMAN RESOURCE DEVELOPMENT

1995 Conference Proceedings

March 2-5, 1995
St. Louis, MO

[13] **INSTRUCTIONAL TECHNOLOGY** Facilitator: C.J. Wallington, Rochester Institute of Technology

The Effectiveness of an Electronic Performance Support System on Learning and Performance
Theo J. Bastiaens, University of Twente (The Netherlands)
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Predictors of Computer-Related Trainee Success and Optimum Training Techniques
Steven John Simon, Oklahoma City University

A Normative Model for Selecting HRD Multimedia
Theresa M. Palmer, Illinois State University
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Computer-Based Instructional Design Principles & the Adult Learner: Guidelines for Future Research
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The Effectiveness of an Electronic Performance Support Systems on Learning and Performance.

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This research is measuring the effectiveness of Electronic Performance Support Systems (EPSS). Some of the major advantages of EPSS, like increasement of productivity and better learning outcomes are evaluated with insurance agents working on laptops. Theoretical statements, research framework and hypothesis are presented. The conclusions are drawn and no significant improvement on productivity or learner results has been seen.

In the last ten years the Computer Based Training (CBT) market grew tremendously and the quality of the programs increased. Sound and vision were added, educational technology improved the design and structure. Nowadays key words are just-in time learning and learning by doing. For that CBT had to be revised and integrated in the workplace. One way to integrate learning in the workplace is using Electronic Performance Support Systems (EPSS). EPSS supports and monitors employees while they are working; but EPSS is not only an alternative for the human master in the master/journeyman paradigm, it is more. EPSS is an integration of all the electronical sources and tools employees need to do their job. Developers and researchers working in the field of EPSS have high expectations. EPSS will improve productivity and learning outcomes. What are their assumptions? A short historical overview of corporate training can help.

Since the early seventies most of the employees in business and industry are trained by classroom instruction. They are treated as a homogeneous group. The master who's the expert teaches the desired knowledge and skills. The problems of classroom instruction are related to costs and benefits. There is a lot of money involved; turnover costs etc. The benefits of classroom instruction are relatively low. Employees have to learn skills in a theoretical way . Learners have problems to relate the classroom instruction to their own specific situation. Reasons to change the paradigm to the good old master/journeyman paradigm. Since the middle ages this paradigm has been proven. At the workplace a master is doing his job. The journeyman observes the master and tries to imitate the him. A cheap and efficient way. Nowadays it is hard to use this paradigm because of the number of employees. But there are some good properties in this training on the job. Related to classroom instruction training on the job is often cheap. Employees don't have to leave their workplace anymore (Jacobs & Mc Griffin, 1987, Jacobs, 1990). The learning processes are more concrete and active (Münch, 1990). The transfer is higher because of the identical situation between the learning environment and the workplace (Wexley & Latham, 1991). All these advantages stay when CBT is used in the workplace. Besides that people can get trained whenever and where they want. But CBT has problems too. Employees have to stop working when they use CBT. Training with CBT is still an separate event (Gery 1989). Employees will benefit from the integration of learning with their job. EPSS is possibly the solution for all the problems stated above. This research will try to explore some conclusions.

EPSS is a concept which integrates the electronical sources employees need to do their job. Employees need tools to perform, they have to look up information quick to use in their job, they want to learn certain subject-matters or skills when needed and they want to get expert advise to guide them through difficult parts of their job. For that reason an EPSS environment exists of four components (fig 1).

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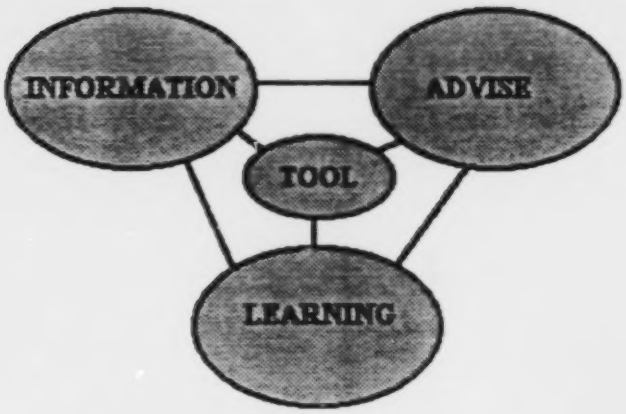
Figure 1. The components of an EPSS.



EPSS provides employees with just-in time knowledge, information and learning at the right moment (Gery 1992). High transfer, no need to leave the workplace and more active learning processes are advantages of training on the job. Specific EPSS advantages are immediate access to information and learning, a reduction of the amount of formal training in advance of task performance and a reduction of the supervisor time spend on employees. It has the additional advantage that the responsibility focus changes from the trainer and training program to individual job specific learning experiences (Gery, 1992). Performance support systems can be important in employees self management or self-directed teams (Bramer & Senbatta, 1993) and will improve the workers productivity (Raybould, 1990, 1991). Law (1994) tries to find scientific evidence for the surplus value of EPSS from current cognitive theory. He relates performance limitations to cognitive explanations. Performance requiring large amounts of factual knowledge, proficiency of skills infrequently utilized on the job or simultaneous processing of a large amount of information have an cognitive explanation. It places high demands on long term memory without adequate processing, declarative and procedural knowledge that decayed or in a limited capacity of the working memory. In Law's opinion EPSS can provide an extension of long term memory and reducing the working memory load.

Problem Statement

In the first paragraph a lot has been stated but little has been proven. This research project attempts to evaluate an EPSS on the effectiveness. In literature a few disadvantages were found. Just-in time training at the workplace, providing employees small task-oriented training granules and employees taking control of their own learning process will create problems. Clark (1992) gathered some subjects we have to take into account. In her opinion employees may fail to build a unified picture of their job when they have to distract information from an EPSS. Several little information parts will create a fragmented knowledge base. Especially novices need a high level overview of the content to relate details of training. She doubts about the learner control in EPSS. She cites research of Milheim and Martin (1991) which proves that learner control is not as effective as instructional control. It is expected that the introduction and implementation of EPSS will summon resistance. Employees are not likely to give up working 'the old way'. And when not, there is an other problem. The pressure in their work. Employees will not have the time to engage the training support. A more philosophical question is related to the long term effects of

EPSS. Will it 'de-skill' workers? Will it 'de-motivate' workers? Or will it automate the low level tasks and bring in more time to perform tasks on higher level (Carr, 1992)?
It is not possible to give answers on to all the questions. In general we want to measure the effectiveness of EPSS. We expect EPSS to be more effective than the "old situation". "Effectiveness" is split up in effectiveness on learning (learner results) and effectiveness on working (productivity). The next section will explain the setting and will further state our underlying expectations.

Research questions

The project is executed in cooperation with a large Dutch insurance company. This company is selling insurance products to their clients by a widespread network of insurance agents. These agents are working for the company on a commission based system. The company administrates the sold products and provides background information and training to their agents. The insurance agents operate from their home office by visiting (potential) clients. The training program exists of an introduction course for new agents and specialized (related to specific products) courses for advanced agents. In general training means classroom instruction, experts provide knowledge, manuals and textbooks to read at home. The training department ascertained this way of training not to be (cost)effective. The expensive courses didn't lead to better outcomes in learner results and productivity. As the policy for the future was to develop a computer tool to communicate better and quicker with their head-office (sending, receiving data), the training department joined a project which provides all their agents with laptop computers in the near future. The idea was born to develop an EPSS for insurance-agents. The EPSS was developed and exists of information, advise and learning about their products. The agent can read information about a product and can automatically calculate with their clients data. The EPSS will give an advise based on the specific situation of the client. The agents support their sales presentation with slides and pictures. They also get Computer Based Training (CBT). The casebased modules enclose all their products. A self test indicates the preparedness of knowledge and skills related to the products. The company expects such an electronically environment to be more effective. To test the expectations three main groups were compared. The first main group is the group working and learning in a traditional way. This group gets a traditional classroom instruction and they work pen/paper based (forms, hand-books) and get information from manuals. The second main group is working and learning with an EPSS. The third group is a control group. For several reasons it was not possible to do preliminary research. So we compare the two treatments (traditional and EPSS) with a 0-group. This third main group didn't have any training and is working on a traditional way. In order to judge about learning and working we split up the treatments in two parts; the first is the working part. It's the tool program in the electronical environment and the forms and hand-books in the traditional way. The second is the learning part; the CBT in the electronical environment and the classroom instruction in the traditional group. To make the description of this research more complex we had to deal with other variants. In table one the groups are stated.

Table 1: Three main groups and their variants.

TREATMENT		n
1	TOOL & CBT (EPSS)	12
2A	TOOL & CLASS	8
2B	PAPER & CLASS	4
3A	TOOL	5
3B	PAPER	7

The main hypothesis "EPSS is more effective than traditional classroom training and traditional pen/paper based working". This thesis is split up in several research questions. The question related to training is; Agents in the EPSS group, trained with CBT, will score higher on a learners test. In other words these agents will have higher learner outcomes. The research question related to working is; agents working with EPSS will score higher on selling. The productivity will increase. As this EPSS is a new system, we are also interested in the evaluation of the components involved, the feedback, the support and the opinion of the users. Answers and questions on these components are important for future development. In this paper we will only try to answer the questions above. Although the next section "methodology" will give an overview of the whole project, we will not go further into the quality of the developed EPSS. At the end we will try to show causes for the outcomes.

Methodology

The data collection in this project is split up in a qualitative- and a quantitative part. Table two shows the method used to gather the information, the target group, the treatment and the amount of persons involved.

At the start of the project we collected the sales results of 1993. To give an opinion about the productivity we used their sales of insurance's in the field of annuity. These insurance's are topics in the CBT and classroom training. At the end of the project their results over 1994 were collected. It was expected that agents using an EPSS would sell more annuities compared with agents not using an EPSS. The next measurements were the interviews (n= 12). Four people of every group were interviewed. They answered on structured questions related to our variables (see next chapter). At the end of the interview they got a case. They had to respond to a practical situation and had to process the data. This practical situation was observed to give insights in people using their computer or manuals and forms. This was done to relate performance differences to productivity and learning results. These learner results were measured on all the agents (n= 36) in a test. They all got the same test on pension insurance's. Next all the agents got a questionnaire (n=36). The questionnaire was separated in two different parts. The first was a general part based on our variables, the second was related to the specific treatment. After they filled up the questionnaire the whole group held a discussion (n= 36). This session was important to collect the ideas of the agents. They have to work all day with EPSS. They know what is effective and what they like. So gathering their experiences is worthwhile. To compare the assertions of the agents we talked to their managers (n=8). What is their opinion about EPSS, productivity and change? They discussed positions related to EPSS. In the section results and conclusions our findings are forwarded.

Table 2. overview of the methodology.

	O1	XA	OA1	O3	O4	OA2	O5	O6	O7	O8
	O1	XB	OB1	O3	O4	OB2	O5	O6	O7	O8
	O1	XC	OC1	O3	O4	OC2	O5	O6	O7	O8
	O1	XD	OD1	O3	O4	OD2	O5	O6	O7	O8

O1	Sales results '93, agents (n=36)
Oa1..d1	Inteview , agents (n=12)
O3	Observation, agents (12)
O4	Learning test, agents (n=36)
Oa2..d2	Questionnaire, agents (n=36)
O6	Discussion, agents (n=36)
O7	Questionnaire, managers (n=8)
O8	Sales results '94, agents (n=36)
XA	TOOL&CBT (n= 12)
XB	TOOL&CLASS (n= 8)
XC	PAPER&TOOL (n= 5)
XD	PAPER (n= 7)

The theoretical construct behind EPSS

A lot has been written about EPSS, less has been proved. From literature a theoretical framework has been constructed. The framework encloses the variables who exert an influence on the EPSS. Work, learning, treatment and background have their effect. In table three we state our variables. Work, learning and background are general. The treatments TOOL, CBT CLASS and PAPER are specific.

Table 3. the framework with an influence on EPSS.

Constructs	Variables
Work	
quality	service, communication, adequate advise, sales talk
productivity	sales results
___attitude towards work	satisfaction, self-confidence
___performance	independency, commercial, daily work
Learning	
way of learning	processing, guidance, study conceptions
Tool	
communication.	interface, support
advising client	advise
obtaining information	time to learn, applicable, studiousness

CBT	
communication	interface
pedagogical/didactic dimensions	structure, experience validity, feedback cooperative learning
general	usability, integration with TOOL
Class	
training and support	training, support
___pedagogical/didactic dimensions	structure, experience validity, feedback cooperative learning
___effects	effects
Paper	
presentation	presentation, support
advise	advise, help
___obtaining information	time to learn, applicable, sources
Background	
personal data	age, sex
experience	educational background, working and computer experience
attitude towards innovation	working with new technology

Results

When an opinion is given about EPSS we combine TOOL and CBT. Traditional working and learning is PAPER and CLASS. To be able to use the data the independence of the groups had to be sure. First this independence had to be tested on age, working experience, educational background and innovation willingness. On age and working experience no significant difference was found (one-way analysis of variances for age, n= 36, p=.45 one tailed and for working experience n= 36, p=.27 one tailed). Also for educational background no significant difference was found. But on innovation willingness the score of the TOOL-group was significantly higher regarding the CLASS group (Mann-Whitney Test, n=9, p=.016 one tailed) and the PAPER group (Mann-Whitney Test, n=12, p=.037 one tailed). A reason for this result is hard to give. It is possible that people in the TOOL group are more affected to the project and more innovative for the reason that they are working with new technology. But the other groups working with new technology (TOOL&CBT, TOOL&CLASS) aren't more innovative than the traditional groups. The conclusion is that there is no difference between the groups except the one above. We take the view that the groups are selected at random.

We had to test the reliability of the items involved. The limit was .60 (Cronbachs Alpha). Because of the size of the groups we had some problems with the reliability of the items. The variables that were useful (alpha > .60) are shown in table four.

Table 4 The variables used

Variable	Alpha
Work	-
Learning	-
Tool	
interface	.75
studiousness	.63
CBT	
interface	.75
feedback	.95
cooperative learning	.95
effects	.63
Class	
training	.87
support	.83
cooperative learning	.76
effects	.94
Paper	
presentation	.83
support	.86
advise	.70
help	.77
obtaining information	.73
Background	
attitude towards innovations	.73

Hypothesis 1 related to support With these items we tested the following hypothesis: Agents working with the computer (TOOL, TOOL&CBT, TOOL&CLASS) like the presentation and the interface of the computer more than the agents working pen and paper based (PAPER, PAPER&CLASS). This is not the case. However agents do like the presentation of their traditional handbooks and form more (Man-Whitney Test, n=36, p=.005 one tailed). The mean rank (15.52 for the computer and 25.27 for the traditional way) shows the advantage for the traditional form. This was supported by results on the interviews. Agents like the traditional presentation more because it is quicker (glancing through a manual) to look things up. Reasons for this preference may have to do with the construction and userfriendliness of the EPSS or the agents are not accustomed to the EPSS yet (they were working with it for four months when the evaluation took place). The used hypothesis was that the computer (TOOL&CBT, TOOL) would support the agents better while they are working compared with the traditional way (PAPER,PAPER&CLASS). The result is that there is no significant difference. The computer didn't support the agent better or worse (Man-Whitney Test, n= 36, p=.29 one tailed). This result is against all expectations. It was expected that the computer would provide a better support than the traditional methods.

Hypothesis 2 related to learning When we looked at the learning part the following hypothesis was stated; agents learning with CBT (TOOL&CBT) like the presentation and the interface of the CBT more than the agents who followed a classroom training and who had to deal with a teacher presentation (TOOL&CLASS, PAPER&CLASS). On the test (Man-Whitney Test, n=24, p=.012 one tailed) the mean rank, 9.25 for CBT and 15.75 for the classroom instruction shows that the presentation of the teacher was appreciated more. In the interviews the most common reason to like traditional classroom training more was the contact with other colleagues. They see training as a social event. In their daily work they don't have contacts with colleagues. They like seeing each other at a training. Now they are afraid that CBT will take them away their social event. The next statement was that agents learning with CBT like to learn alone (TOOL&CBT), . Agents in classroom instruction like to learn together with other colleagues (TOOL&CLASS, PAPER&CLASS). The answer on this hypothesis is that this is right. Agents in the classroom instruction do like to learn in cooperation with others and agents learning with CBT do like learning alone (Man-Whitney Test, n=24, p=.0007 one tailed). The last hypothesis related to learning was agents learning with CBT (TOOL&CBT) think that they learn more effective than agents in classroom training (TOOL&CLASS, PAPER&CLASS). In fact agents in classroom training think that they learn most effective in this way. The hypothesis is not true. CBT is not appreciated as most effective (Man-Whitney Test, n=24, p=.050 one tailed).

Next we looked at the results on the learning test. The test was split up in a case and in questions to test their knowledge. In the practical situation the agents had to give an ideal advise to a fictionary client. With this case the quality of the solution is measured. With the questions their background knowledge was tested. Both are important in their daily work. When we look at the results of the cases and we compare the groups trained with CBT (TOOL&CBT), classroom training (TOOL&CLASS, PAPER&CLASS) and no training (TOOL&PAPER) we see that there is only a difference between training and no training. Classroom training compared with no training shows a significant difference (T-test, n=24, p= .043, separate variance one tailed). CBT compared with no training also shows a significant difference (T-test, n=23, p= .018, separate variance one tailed). In both cases training was more effective than no training. this is not surprising. The difference on the case between CBT and the classroom training was not significant (T-test, n= 23, p= .24, separate variance one tailed). Conclusion is that it doesn't matter whether agents were trained with CBT or in a traditional classroom. When we look at the questions to test their background knowledge there is no difference between the group with CBT and the group with classroom training (T-Test, n=23, p=.149, separate variance one tailed). There is a significant difference between classroom training and no training ((T-Test, n=24, p=.009, pooled variance one tailed). The score of people that were trained was higher. CBT compared with no training didn't show a significant result ((T-test, n= 23, p= .060, separate variance one tailed).. That is remarkable. The standard deviation causes this effect (CBT standard deviation = 27.67, no training 41.860). The overall conclusion is that there is no significant difference between CBT and the traditional training.

Hypothesis related to work The company is training people to make more money in future. The next part will compare the sales results between the three groups. We only looked at one part of their sales. This results are related to the sold annuities in 1993 and 1994. Several other influences (like a difference in the political situation in the Netherlands) were not measured. It is hard to relate these results to the treatment. Knowing that these results are not only caused by the treatment we carefully state the following: the productivity of the group learning with the computer will be significantly higher in 1994 (the year they started working with the computer). First a comparison between the sales in 1993 and 1994 took place. The significant difference between the two years were split up between the groups (CBT, classroom training and no training). A one-way analysis of the variance was not significant (n= 36, p=.230, one tailed). The conclusion is that there is no difference in sales between the groups. It doesn't matter whether agents are trained or not, it has no significant effect on the selling of annuities. Finally we test the hypothesis whether agents working with the computer sold more than agents working pen/paper based in 1994. The group working with new technology (TOOL&CBT,

TOOL&CLASS, TOOL) and the group working in a traditional way (PAPER&CLASS, PAPER) were compared on their selling results. The expectation is; agents working with new technology will sell more in 1994 than agents working in a traditional way. This hypothesis seems not to be true (T-Test, n= 36, p=.23, one-way). There is no significant difference between the two. Working with the computer will not result in a higher productivity on annuities. Did the agents sell anything more at all in 1994 ? Yes, they did, but not all of them. The CBT group didn't sell significantly more (paired T-Test, n=12, p=.055). The group trained in a classroom situation did have a higher productivity (paired T-Test, n=12, p=.0014). The group without training did also do significantly better (paired T-Test, n=36, p=.015). The way people work didn't have any special influence. The group working with new technology has higher results in 1994 (paired T-Test, n=25, p=.003). The group working in a traditional way scored significantly higher too (paired T-test, n=19, p=.0052). The overall conclusion training doesn't contribute anything to the productivity in this situation.

Conclusions

We tried to evaluate the effects of EPSS on learning and productivity. The setting was a large insurance company in The Netherlands. This project was a pilot project. This pilot had a lot of limiting conditions. But that is not unusual in this type of research. Although we would have loved larger groups. We tried to measure EPSS in the field were the surplus value is expected. For that a framework was developed. In the framework are variables which have an impact on the effectiveness of the EPSS. The expectations in the first chapter were tested. In general the EPSS in this project is not so successful as in literature often is stated. This EPSS did have information, learning and advise. Although the researchers have some remarks on the development of the EPSS, it is not a badly constructed one. Maybe the integration of the CBT can be better (those small granules) but this lack of integration is not the reason that agents don't like the EPSS a lot when they have to learn with it. Of course there are reasons, like the social event reason, not related to the effects. But also on the effects the influence of EPSS is hardly measurable. Productivity doesn't increase. The learners results are almost the same as in the traditional situation. An advantage as just-in time learning is hard to see. Agents don't have the time to look up information. They postpone training. As a result the just-in time training becomes inadequate working. The employees didn't take the responsibility for learning . In future the direct managers has to take the responsibility for their learning. The advise and information part of the EPSS didn't do any better than the traditional manuals. The agents thought it is quicker to look up information in books. The overall conclusion is they like the old way better. What are the reasons for it. Is this the expected resistance? No, they told us some good things. They like the automation of certain tasks, like the fill up of forms and counting the benefits for their clients. As is stated by Carr (1992) they know have the time to do other things, like talking to their clients. And that is important. The agents also like it that they now have the possibility to show or present something to clients. This was harder in the traditional situation. Now they feel more professional and a client is trusting them more. Positive findings of EPSS haven been seen in the project. These advantages are on the whole related to controlling the costs. There is no direct improvement of productivity and learner benefits. Further research has to be done to improve EPSS and prove these findings in other settings.

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Principles of CBI Design and the Adult Learner: The Need for Further Research

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The increasing use of computer-based instruction in HRD applications is accompanied by a growing need for guidelines directing its effective design and use. Current research has failed to provide this guidance. Research deficiencies include a limited number of studies in many areas, contradictory findings, and questionable generalizability to adults in the workplace due to an almost exclusive use of students college age and younger as research subjects.

The development of faster, less expensive, more adaptable and more user-friendly microcomputers which can incorporate a wide range of software capabilities such as sound, graphics, and video has made a computer revolution in education and training a dramatic possibility. It has been predicted, for example, that, by the end of this century, most of our children's education will take place via computer (Lepper, 1985) and that 50% or more of all industrial training will involve computers by the year 2000 (Harrington, McElroy, & Morrow, 1990). Such expectations call for research aimed at identifying specific variables related to the effectiveness of computer-based instruction as an instructional methodology.

Computer-based instruction (CBI), or the process of instruction in which a computer is used to present instructional materials to a learner, has been studied diligently for more than three decades. The research suggests that, across content and educational levels, CBI is effective in improving performance and attitudes toward instruction as well as accomplishing the same learning objectives as conventional instruction in significantly less time (Dalton, Hannafin, & Hooper, 1989). However, the research on CBI and related variables has been conducted predominately in formal classroom settings with subjects college age or younger. Few studies aimed at assessing the effectiveness of CBI or identifying specific variables related to the effectiveness of CBI as an instructional methodology have been confirmed with adults above college age. Thus, while the literature suggests principles of effective CBI, a cogent question remains to be answered: To what extent are these principles applicable to adults in general and, specifically, to adults in a workplace setting?

Accompanying the increasing popularity and application of CBI in human resource development (HRD) contexts must come a clear understanding of whether or not the design principles we are relying upon are solidly grounded. The purpose of this paper therefore is to survey the research literature to identify the principles of effective CBI ; assess the adequacy of this research in terms of adult populations, particularly adults in the workplace; and make recommendations for a research agenda as related to CBI, adults, and the workplace.

General Research Findings

Learner Control of CBI A major advantage of CBI is seen in its ability to adapt to the individual needs and abilities of learners. One significant aspect of this adaptability is the potential of CBI to offer learners differing degrees of control over lesson pace, sequence, content, or quality of instruction;

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amount of lesson practice or review; the form, frequency, or content of feedback; when to test; when to terminate instruction; or some combination of these variables.

The issue of learner control is seen by some as the most important design issue in CBI (Jonassen & Hannam, 1987). Providing such control allows the learner to guide the response of the instructional program to suit that individual's needs as he or she perceives them (Williams, 1993; Taylor, 1987). The underlying assumption of learner control is that the learners themselves are best able to determine the type of instruction needed for effective learning. Providing for some degree of learner control therefore leads to enhanced learning performance.

However, the research results regarding the impact of learner control on learning performance in CBI are mixed. Some authors have found performance in terms of learning and retention to be significantly higher under learner control, as compared to more passive, program control (Ellerman & Free, 1990; Carrier & Williams, 1988). Others (Dalton, 1990; Kinzie & Sullivan; 1989) have found no difference in learning performance between learner control and program control. Still others (Pollock & Sullivan, 1990; Lee & Wong, 1989) have found learner performance under various forms of program control to be superior to that under learner control. There is some evidence that the equivocality of these findings may be dependent on a number of individual learner characteristics such as prior knowledge (Shaw, 1992), cognitive ability (Kinzie, Sullivan, & Berdel 1988), motivation (Morrison, Ross, & Baldwin, 1992), cognitive style (Carrier, Davidson, Higson, & Williams, 1984), or personality type (Kern & Matta, 1988).

Group Methods in CBI The potential that CBI offers for one-on-one interaction (one learner-one computer) has been forwarded as a major advantage of this instructional technology. This view asserts that learning is best in CBI when there is one student working with one computer because individual learning needs can be identified and addressed as well as individualized feedback and reinforcement developed and administered (Williams, 1993). However, some current research challenges this perspective. Webb (1987), for example, reviewed 14 studies comparing group and individual methods of instruction in CBI and found no study in which significantly greater learning occurred when students worked alone. Stephenson (1992), studying college business students in a spreadsheet CBI tutorial, found that students in dyads outperformed all individualized conditions. Dalton, Hannafin, and Hooper (1989) found that learners working in pairs significantly outperformed individuals in computer-aided instructional lesson. Johnson, Johnson, and Stanne (1985) found learners working cooperatively in groups of four produced a greater quantity and quality of daily work and demonstrated greater problem-solving skills than learners working individually or competitively. This and other research suggests that the nature of the interpersonal interaction present when groups of individuals work cooperatively is an important component in the effectiveness of CBI. Peer interaction, for instance, has been found to encourage high level elaboration (i.e., explaining) between students which leads to greater learning gains (Webb, Ender, & Lewis, 1986). Students working together in CBI have also been found to be able to produce ideas that individuals are unable to generate on their own (Webb, 1987) and to learn from others by observing and imitating the methodologies other students use in problem solving or task completion (Hythecker, Rocklin, Dansereau, Lambiotte, Larson, & O'Donnell, 1985).

Feedback in CBI Feedback is commonly defined as information provided to learners following a response that is intended to help the learner locate errors and correct mistakes (Schimmel, 1988). Feedback has been earmarked as one of the critical variables in the design of effective CBI because of the computer's capability to consistently provide a wide range of feedback information (Clariana, Ross, & Morrison, 1991). The limited research conducted on feedback in CBI focuses on performance improvement and comparisons of different feedback techniques. These techniques vary along a number of qualitative dimensions including content, frequency, and timing.

Feedback Content. Feedback content refers to the information provided to learners about the appropriateness of their response relative to the instructional content. The informational content of feedback is generally thought of as lying along a continuum of explanatory complexity from simple confirmation ("correct" or "try again") to various types of explanatory feedback (Schimmel, 1988). Several studies have compared the effects of various forms of feedback content on learning (Clariana, 1993a; Kim & Phillips, 1991). This research supports a hierarchy of feedback content which says that no feedback is less effective in terms of improving performance than confirmatory feedback which is less effective than explanatory feedback. Other evidence suggests that this hierarchy is not so well established and that the provision to learners of extensive information about why their answers are wrong is no more

effective than offering minimal information (Schimmel, 1983). The overall implication of these findings is that the optimum level of feedback information may depend on the instructional setting, instructional content and objectives, and the individual needs of the learners.

Feedback Timing. Feedback timing has to do with when in the process of instruction feedback is delivered. Feedback may be provided either immediately after a learner's response or delayed for a period of time or number of responses (Clariana, et. al., 1991). The available research addressing the effect of feedback timing in CBI is limited and the results of what has been done are mixed. Some research points "toward small to moderate positive effects of immediate feedback' in the acquisition of behavior (Kulik & Kulik, 1988, p. 93). Other studies have demonstrated that the delay of feedback facilitates both acquisition of knowledge and the retention of learning (Gaynor, 1981; Sturges, 1978). Thus, whereas immediate feedback remains the most common feedback timing convention in CBI there is evidence that some delay of feedback may be superior under certain conditions.

Feedback Frequency. Frequency of feedback in CBI deals with the amount of information supplied by feedback as well as the technical possibility of applying feedback once (for example, after the first response), a second time consequent to a second try by the learner, or to allow the learner to continue making attempts followed by feedback until a correct answer is obtained (Clariana, 1990). Some writers have suggested that a multiple-try or answer-until-correct feedback strategy may improve learning performance to the extent that it engages the learner in additional cognitive processing following incorrect responses (Clariana, 1993b). Only limited research has been aimed at testing whether one or many responses with accompanying feedback is more effective. The findings of this research indicate that there is no significant difference in performance of learners with single-try versus multiple-try feedback.

Computer Anxiety Computer anxiety refers to a state characterized by a "fear of impending interaction with a computer that is disproportionate to the actual threat presented by the computer" (Howard, Murphy, & Thomas, 1987, p. 14). This state involves an array of physiological, attitudinal, and emotional responses that may occur when individuals interact or expect to interact with computers.

The current research on computer anxiety is inconclusive on two issues. First, to the extent that an individual's performance in any given situation is a function of his or her physical, emotional, or attitudinal state, computer anxiety is considered an important variable in CBI. This presumption is based largely on a rather extensive history of research linking high anxiety in general to decreases in performance and learning (Tobias, 1979). Although some research indicates that negative emotional reactions to computers can have a detrimental impact on the extent to which computers can be effectively used (Marcoulides, 1988) other studies provide contradictory evidence. Bracey (1988), for example, found a positive .71 correlation between computer anxiety and achievement in a computer information systems course.

A second unresolved issue has to do with the degree to which the rapidly increasing use of computer technology has been accompanied by a similar increase in the number of people who feel anxious about using computers. Some studies (Elder, Gardner, & Ruth, 1987; Glass, & Knight, 1987) show that from 30 to over 50% of respondents report attitudes indicative of computer anxiety. Other research (Massoud, 1991; Lewis, 1988) suggests that these figures overestimate the extent of computer anxiety and, moreover, that some populations are relatively unaffected by computer anxiety and have fairly positive attitudes towards computers. In sum, although the assumption persists that computer anxiety is an important variable in CBI, the research evidence is far from conclusive in terms of identifying or confirming its impact on performance as well as its presence across populations and settings.

Screen Design Screen design as a variable in CBI incorporates components such as text density, screen density, layout and location of information, and legibility. The literature in this area is largely propositional with only a few studies focused on determining if these components make a difference in learning. As with many of the studies done in computer based instruction, most of these studies have been done with student populations.

Text Density. Text density refers to the amount of information presented on the screen. High density text is assumed to provide more content-related information and more in-depth explanation of the information while low density text generally uses a more abbreviated outline format. Two studies (Morrison, Ross, O'Dell, & Schultz, 1988; Ross & Morrison, 1988) conducted with undergraduate teacher education majors examined the impact of text density on learning. Both of these studies found no significant difference in learning attributable to different text density levels.

Screen Density. Screen density refers to the proportion of print to white space on a computer screen. Some research suggests that learner preferences for screen density vary and that screen density may impact the efficiency of learning. Morrison, Ross, O'Dell, and Schultz's (1988) study of undergraduates found that learners preferred moderate white space and did not like the text spread over a relatively large number of screens because it forced them to switch screens too often. Other studies have established that reading efficiency in CBI is improved when text is double spaced (Hooper & Hannafin, 1986). No studies to date, however, have established a relationship between the degree of screen density and improved learning performance.

Location of Information. Martindale (1993) has argued for text schemas in CBI based on the assumption that text structures that are consistent over a range of programs or lessons ease progression through a lesson and facilitate the acquisition of information. Hooper and Hannafin (1986) have similarly argued that the integration of instructional content with consistent schemata and frame design in CBI helps to cue appropriate cognitive behavior and promote memory retrieval. The sparse research that has addressed these issues indicates that the consistent placement of information on a computer screen does help in the transfer of information and improvement of learning, suggesting that the location of information serves as a mediator of recall and functions as a cue to help organize memory search (Aspillaga, 1991).

Legibility. Legibility, or the ease of reading material from a computer screen, includes three variables - justification, line length, and leading. Justification has to do with line length and the amount of space between words. Full justification makes all lines the same length by varying the space between words; flush left justification has equal spaces between words but produces lines of varying length; and centered justified equally spaces words and balances the text around an imaginary line down the center of the page. The research on justification shows left justified text to be the most efficient convention, reading faster than both centered or full justified text (Hooper & Hannafin, 1986).

Line length deals with the optimum number of characters that can be displayed on a single horizontal line. Little or no research has been done in this area of CBI and, although some authors suggest that text is read more efficiently when presented with greater density (for example, 80 as opposed to 40 characters per line), the issue of what line length is best has not been settled.

Leading refers to the space between lines in computer generated text. As previously noted, several studies have reported that reading efficiency is increased when text is double spaced (Hooper & Hannafin, 1986).

Color, Graphics, and Animation. The increased technical capabilities of computers has made the incorporation of color, graphics, and animation into CBI a relatively simple task. Although these features of CBI can be impressive and easily draw a learner's attention, the question of whether they improve learning remains largely unresolved. For example, Baek and Layne (1988) found that the addition of color, while aesthetically pleasing, did not improve learning in a CBI lesson but that both graphics and animation did. Such gains in learning with animation are not, however, consistent across studies. Rieber (1990) reviewed 12 studies using animation and found no difference in learning in CBI with animation in 6 of those studies. On the other hand, it was noted that the students in lessons employing animation took significantly less time to answer questions covering lesson content. This may indicate that animation aids in the organization of material during the acquisition of information and in the reconstruction of material during retrieval.

CBI Research and Adult Learners

Learner Control The research on learner control in CBI has shown that such control is not unconditionally effective as a strategy to improve learning performance and that various individual traits appear to influence the impact of learner control on performance. This research leaves unresolved the more specific issues of what degree of learner control is best under which circumstances and with which learners, particularly adult learners above college age. Most of the studies in this area have been conducted with college age subjects or younger. For example, from the 28 studies reviewed for this paper only 2 reported results from subjects above undergraduate college age and over half (n=15) were conducted with high school age subjects or younger. Of the 2 studies done with adults, Ellerman and Free (1990) found higher levels of instructional sequence control in paired associate learning to be correlated

with significantly better learning performance in subjects whose mean age was 27. Similar results were found for a group of students with a mean age of 23. A major conclusion of Shaw (1992), based on 6 years of research with computer-aided instruction at the U.S. Army Construction Engineering Research Laboratory was that, under CBI, adults are best served with relatively greater degrees of instructional control. Shaw summarized her research by stating that CBI "targeted at adult professionals who are evaluated on the basis of job performance and who need to learn while they work must be quite different from instructional programs for school children, whose objectives are subject matter mastery and whose evaluations are test scores" (p. 57).

In addition,, the contradictory findings with regard to learner control have been interpreted to indicate that some learners may lack the metacognitive skills to use instructional control effectively (Williams, 1993). To the extent that adult learners can be presumed to have developed more refined and effective cognitive strategies this interpretation suggests that adults may be better able than younger subjects to profit from learner control of instruction in CBI. Penland (1979), for instance, suggests that adult learners may prefer learner controlled instruction because they can set their own leaning pace, use their own style of learning, keep the learning strategy flexible, and impose their own structure on the learning project. Again, these and other questions regarding learner controlled CBI with adults in various settings have not been empirically tested and remain in large part unanswered.

Group CBI There is a rich body of research supporting the use of group methods as a means to promote effective learning in CBI. The general implication of these findings is that it is possible to design effective group-centered CBI for a wide range of learners. For example, different types of group interactions, including receiving explanations, making suggestions, and providing answers to specific questions, have been consistently found to be positively correlated with achievement gains among college age subjects (Webb, 1987). Whether these types on group interactions will be equally effective with learners above college age or adults in the workplace is largely unknown. No work currently in the literature has been done to investigate the ways in which the design or function of cooperative learning in CBI affects adult learners in different settings. The research thus leaves many questions unanswered regarding the effectiveness or dynamics of group CBI with adults, the optimum groups size for adults, or ways in which software can be designed for effective small group use with adults.

Feedback in CBI Nearly all of the feedback studies conducted have involved subjects of college age or younger leaving unaddressed many questions about the relationship between adult learners and the qualitative aspects of feedback in CBI. In general, the research conducted in this area suggests that instructional designers should seek "to encourage the mindful engagement most appropriate for the individual learner" (Clariana, 1993b, p. 71). This declaration, while confirming that different learners may have different preferences for different types of feedback, provides little guidance for the design and application of appropriate feedback in different settings with different learners. There are many ways, for example, in which adult learners may differ from younger learners in their feedback needs and preferences. In terms of feedback frequency, it is conceivable that the metacognitive abilities of adults allow them to make use of the additional information provided by multiple-try feedback while that same frequency of feedback may hinder the performance of less experienced learners. It is similarly possible that, to the extent that a differential in the effectiveness of feedback timing exists across populations, such a differential correlates with age. Cohen (1985) suggested that the metacognitive abilities of adult learners are better suited to delayed feedback, particularly that provided at the end of a lesson, because they are better able to use the information at that point in the lesson to summarize and organize information and to assess how they are progressing. The metacognitive abilities of adult learners may also enhance the effectiveness of more complex as opposed to simple confirmatory feedback. In short, despite its implicit value, feedback remains one of the least explored variables in terms of the nature of its impact on adult learning performance in CBI.

Computer Anxiety There is speculation in the literature about the negative effects computer anxiety may have on the self-worth or self-esteem of learners (Morrow, Prell, & McElroy, 1986), its power to alienate workers from their jobs (Elder, et. al., 1987), or even to lead to acts of subversion in the workplace (Baumgarte, 1984). It may be similarly speculated that adults in the workplace will exhibit higher levels of computer anxiety to the extent that they perceive computers as a threat to job performance or job security. Or that adults who view computer expertise as something that will improve their job performance will be relatively unaffected by computer anxiety. These views, however, are largely unsubstantiated by research. Indeed, there is little research establishing the incidence of computer

17 BEST COPY AVAILABLE

anxiety across populations and settings, documenting the effects of computer anxiety on the human-computer interface, or the specific impact of computer anxiety on adult learning in CBI. More research is needed addressing these and other questions so that we may verify whether and to what extent computer anxiety threatens productivity and learning in situations in which computers are used for work or instruction.

Screen Design Most of the research done in the area of screen design has been done with samples from student populations. Intuitively, there is reason to question the applicability of these findings to adult learners because as individuals age, physical changes in eye sight, coordination, and reflexes naturally occur. These changes may, in turn, effect the impact of screen design elements on learning. For example, changes in visual acuity has implications for screen clarity and text legibility (print size, color, and so on) and its impact on efficiency of reading the computer screen. Older learners may therefore profit instructionally from larger print or more dramatic color distinctions. The cognitive or learning style differences of adult learners may have implications for the use of animation. Reiber (1990), for example, cited several studies conducted with adults and animation in CBI which collectively indicate that adults may be better able to visualize information and are therefore less dependent on visual aids such as animation or graphics. Similarly, the experiential or metacognitive differences adult learners may indicate a preference or need for less instructional support information during learning. If so, this would have implications for schema development in CBI and the amount or location of information presented on CBI screens.

Conclusion

Computer-based instruction is without question an increasingly popular instructional medium for adult educators and HRD practitioners. Accompanying the growing use of CBI is a concurrent need for solidly grounded design principles to assist us in the use of this technology. This brief survey of the literature has underscored two major shortcomings found in the research on CBI. First, in areas of learner control, feedback, and screen design existing studies are either very limited in number or the findings are inconsistent and inconclusive. As a result, there are few well established technical or didactic guidelines for designing effective CBI for different content areas, settings, or with different learners. Secondly, the findings that have been adequately confirmed are difficult to generalize to adults because the research in these areas has been done almost singularly with subjects of college age or younger. For example, of the 514 studies reviewed directly and in literature reviews for this paper, 467 were done with subjects of college age or younger while only 47 were done with adults. This emphasis is understandable to the extent that students represent a readily available and inexpensive population from which to draw the necessary research samples. Although the findings from studies employing these subjects may not be inaccurate, generalizing these results to adults is not readily justifiable either in terms of relevance to workplace problems or in terms of sample representativeness. The combined effect of these two shortcomings, limited research -based guidelines and findings suspect in terms of generalizability, raises questions about the usefulness and acceptability of current CBI design principles for adults in the workplace. Research examining the application of CBI variables in organizational settings with non-student populations is needed to extend the generalizability of current findings.

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